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ABSTRACT

This paper, presented at the 1979 meeting of the American Educational Research Association (AERA), investigates the relationship between self-assessment of knowledge and performance, and mathematical aptitude. One hundred college students (51 females, 49 males) participated. Participants, grouped according to mathematical aptitude, were administered a mathematics confidence scale consisting of 18 problems to which they responded by indicating how confident they were that they could solve each problem if asked to do so. Then they worked on 18 similar problems and indicated how confident they were that each solution was correct. Results indicated a clear relationship between mathematical aptitude and the discrepancy between confidence and performance. The lower the aptitude, the poorer the performance at a given confidence judgment. Estimates remained poor even after the problems were attempted, especially on complex problems. Educational implications are discussed. (HM)

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MATH CONFIDENCE AND PERFORMANCE AS A FUNCTION OF INDIVIDUAL DIFFERENCES IN MATH APTITUDE*

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Informal observations in our classrooms over the past few years have suggested a growing number of students who appear to be poor judges of their knowledge about content to be covered on a forthcoming examination. These students often express uncertainty about their preparedness for an exam and, even after the benefit of feedback from actually taking the exam, they give inaccurate estimates of how well they had performed. These observations led us to speculate on some of the conditions which govern the degree to which students can make valid assessments of their knowledge and performance.

Since the apparent increase in poor self-assessment skills coincided with a rather sudden decline in Scholastic Aptitude Test scores among our students, we developed the working hypothesis that the ability to make accurate knowledge and performance estimates may be related to individual differences in aptitude. This hypothesis was tested in the present experiment by examining how well students with different math aptitude scores could predict their performance prior to and following attempts to solve a series of math problems. A direct relationship between aptitude and self-assessment was hypothesized: The lower the aptitude, the poorer the assessment of knowledge and performance.

*Paper presented at the Annual Meeting of the American Educational Research Association, San Francisco, April, 1979.

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METHOD

Participants

One-hundred students (51 females, 49 males) enrolled in an introductory psychology course served as participants in the experiment. The students were divided into 4 groups of 25 each on the basis of their scores on the mathematical section of the Scholastic Aptitude Test. The range and mean for each group were as follows: Low Aptitude (350-490, $\overline{X}$ = 430), Medium Low Aptitude (490-550, $\overline{X}$ = 519), Medium High Aptitude (550-590, $\overline{X}$ = 570), and High Aptitude (590-690, $\overline{X}$ = 628).

Instrument

The Mathematics Confidence Scale (MCS) was used to assess the relationship between confidence and performance (Dowling, 1978). The scale consists of 18 problems to which students respond by indicating on a five-point scale how confident they are that they could answer a given problem correctly if asked to do so. The following scale values are used: "5" ("Complete confidence"), "4" (Much confidence"), "3" ("Some confidence"), "2" ("Very little confidence"), and "1" ("No confidence at all"). Students are then asked to solve a second set of 18 problems each of which is similar to one of the problems used to measure pre-confidence ratings. Finally, the MCS was expanded in the present experiment to include post-confidence ratings indicating how confident the students were that a given problem was answered correctly.

Three different components of mathematics (arithmetic, algebra, geometry), three mathematical demands (computation, comprehension, application), and two problem contexts (real, abstract) are represented

on the MCS. In the present study, the relationship between confidence and performance was analyzed as a function of the three mathematical demands (6 items each) summed across components and contexts.

Procedure

Testing took place during a regular class meeting. The participants were informed that the purpose of the experiment was to investigate the relationship between math confidence, performance, and a number of student characteristics (high school grades, number of math courses, math aptitude, and sex). They were then given the first portion of the MCS, asked to examine each problem carefully for about 20-30 seconds, and then indicate on an accompanying answer sheet how confident they were that they could solve each problem (pre-confidence ratings). The students were then given 18 problems to solve and encouraged to take as much time as they needed to finish all problems. They were also instructed to indicate, after completing each problem, how confident they were that the problem had been answered correctly (post-confidence ratings).

Data Analysis

The procedure followed in the data analysis was to examine the number of correct and incorrect answers on the math problems as a function of pre- and post-confidence ratings and math aptitude. As an example, the pre-confidence analysis for a given student might have included no ratings of "1" ("No confidence at all"), one rating of "2" ("Very little confidence") with the corresponding problem being answered incorrectly, three ratings of "3" ("Some confidence") with one

of the corresponding problems solved correctly, eight ratings of "4" ("Much confidence") with six correct answers on the corresponding problems, and six ratings of "5" ("Complete confidence") with all corresponding problems correct. The post-confidence analysis for this student would take the same form except that the ratings given after the problems had been attempted would serve as the basis for determining the number of correct and incorrect answers at each confidence rating. These analyses yielded the number of correct and incorrect answers at each confidence rating for each aptitude group. Chi-square tests were used to determine significant differences among groups as a function of rating category and mathematical demands.

RESULTS

Preliminary analysis revealed relatively few low confidence ratings ("No confidence at all", "Very little confidence") either before or after the problems were attempted. Moreover, performance on those problems associated with low ratings was found to be unrelated to math aptitude, and more often than not the problems were not even answered. In effect, then, all students could readily identify problems about which they knew very little, usually did not even guess at the correct answer and, not unsurprisingly, very little discrepancy was found between confidence and performance in these cases. Subsequent analysis was therefore directed toward those instances in which positive confidence ratings were made ("Some confidence", "Much confidence", "Complete confidence"). Overall, 3035 confidence ratings were made within these categories, 77 percent of which were associated with correct answers in the pre-confidence analysis

and 81 percent in the post-confidence. Sixty-one percent of these ratings were "5's" ("Complete confidence"), 22 percent were "4's" ("Much confidence"), and 17 percent were "3's" ("Some confidence").

Overall Analysis

Performance on the 18 math problems for each aptitude group at each confidence rating is shown in Fig. 1. (Although statistically analyzed in terms of the number of correct and incorrect answers, the data are presented as percentages because of unequal numbers of responses for each aptitude group.) The white bars indicate the performance-confidence relationship as

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Insert Fig. 1 about here

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a function of pre-confidence ratings. Black bars depict the relationship for post-confidence ratings. For example, on those problems for which "Complete confidence" was expressed in the pre-confidence ratings (right-hand panel, white bars), 66 percent of the problems were answered correctly by the Low Aptitude group. This group was correct on 79 percent of the problems about which they expressed "Complete confidence" after the problems had been attempted (black bars). By way of contrast, the performance accuracy of the High Aptitude group was, respectively, 90 and 95 percent.

Clear trends can be seen at each confidence rating. The lower the aptitude, the poorer the performance even on problems about which "Complete confidence" was expressed, and even after students had the benefit of feedback on their own performance.

Chi-square values based upon an analysis of correct and incorrect

answers for each aptitude group at each confidence rating are shown in Table 1. All pre-confidence analyses were statistically significant. However, it should be noted that although the trends were the same for all post-confidence analyses, only the analysis for ratings of "Complete confidence" reached an acceptable level of significance.

Table 1

Chi-Square Values For Each Confidence Rating (Pre and Post)

	"Some"	"Much"	"Complete"
Pre	14.75[c]	7.91[b]	39.87[d]
Post	3.72	7.68[a]	25.91[d]

[a] $p < .10$ [c] $p < .01$
[b] $p < .05$ [d] $p < .001$

Performance and Mathematical Demands

The percent correct answers for each aptitude group as a function of both confidence ratings and mathematical demand (Computation, Comprehension, and Application) is shown in Fig. 2. Although similar trends are apparent for each type of demand, it can be seen that the effect is most dramatic for Comprehension and Application problems. It would appear that all students are able to assess correctly their performance on relatively easy problems. On more difficult problems, however, the lower the aptitude the poorer the assessment of both knowledge and performance.

Insert Fig. 2 about here

A summery of chi-square values for each analysis is presented in Table 2. (Cell frequencies were too small in four cases to permit an appropriate test.) Both pre- and post-confidence analyses were significant for Comprehension and Application problems as was the present in all cases but only the analysis on pre-confidence ratings of "Some confidence" reached statistical significance.

Table 2

Chi-Square Values For Each Confidence Rating And Mathematical Demand (Pre and Post)

	"Some"		"Much"		"Complete"	
	Pre	Post	Pre	Post	Pre	Post
Computation	*	*	*	*	10.69[b]	2.21
Comprehension	2.53	1.29	2.50	3.61	15.29[c]	29.28[d]
Application	8.03[a]	2.75	4.41	4.04	24.07[d]	20.18[d]

* insufficient data
[a] $p < .05$
[b] $p < .02$
[c] $p < .01$
[d] $p < .001$

DISCUSSION

The results of the present experiment provide support for the hypothesis that self-assessment of knowledge and performance are related to aptitude. Especially on complex mathematical problems, low math aptitude students were poor judges of how much they knew and, even after the benefit of feedback from their own problem solving activity, they made relatively inaccurate performance estimates.

Although alternative explanations of the results have not been completely ruled out and the generality of the findings await further empirical test, we believe that the results have some important implications for teaching low aptitude students. If these students are indeed unable to make accurate judgments of their knowledge, it follows that they would have a very difficult time determining when they are or are not prepared to take an examination. This lack of judgment rather than an inherent cognitive deficit may account for a substantial portion of their poorer examination performance. If so, our efforts to enhance the performance of low aptitude students might focus on the provision of aids for self-assessment instead of what has been largely unsuccessful attempts to raise aptitude scores.

Exactly how to enhance the accuracy of self-assessment of knowledge remains problematic. There is evidence that the performance of low aptitude students can be enhanced with highly structured teaching formats which include clear objectives, frequent and immediate feedback, and opportunities for remediation (e.g., Morris & Kimbrell, 1977; Pascarella, 1978). We believe that these added supports mediate their effects through the facilitation of self-assessment processes. Of course, a clear relationship between performance and self-assessment remains to be demonstrated. Future investigations will search for a causal relationship and attempt to identify the optimal conditions for enhancing self-assessment skills.

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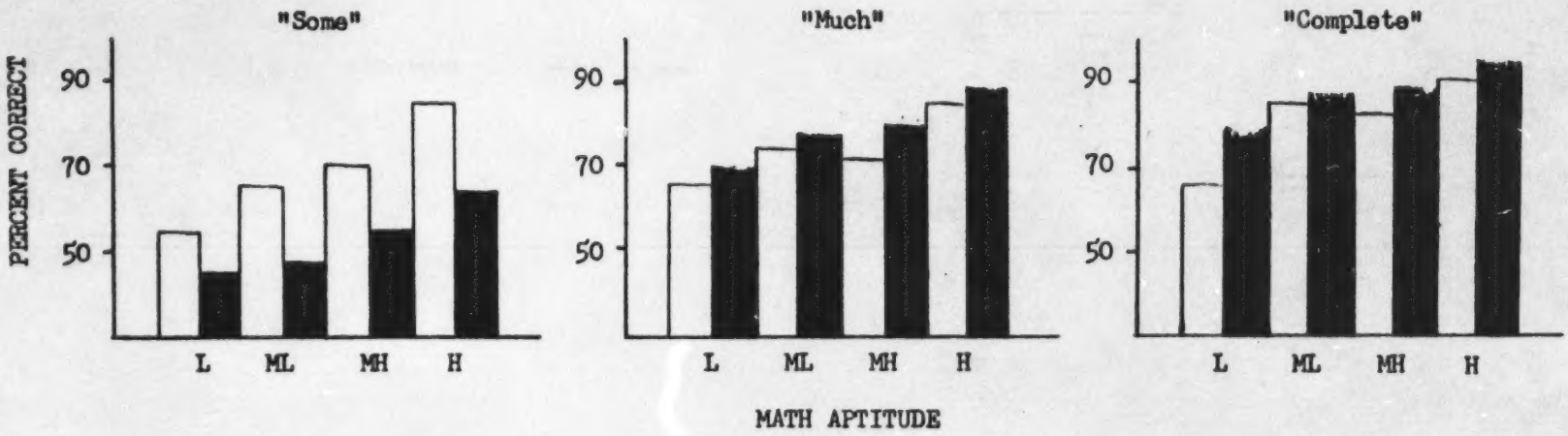

Fig. 1. Percent correct answers for each aptitude group as a function of confidence rating, pre (white bars) and post (black bars).

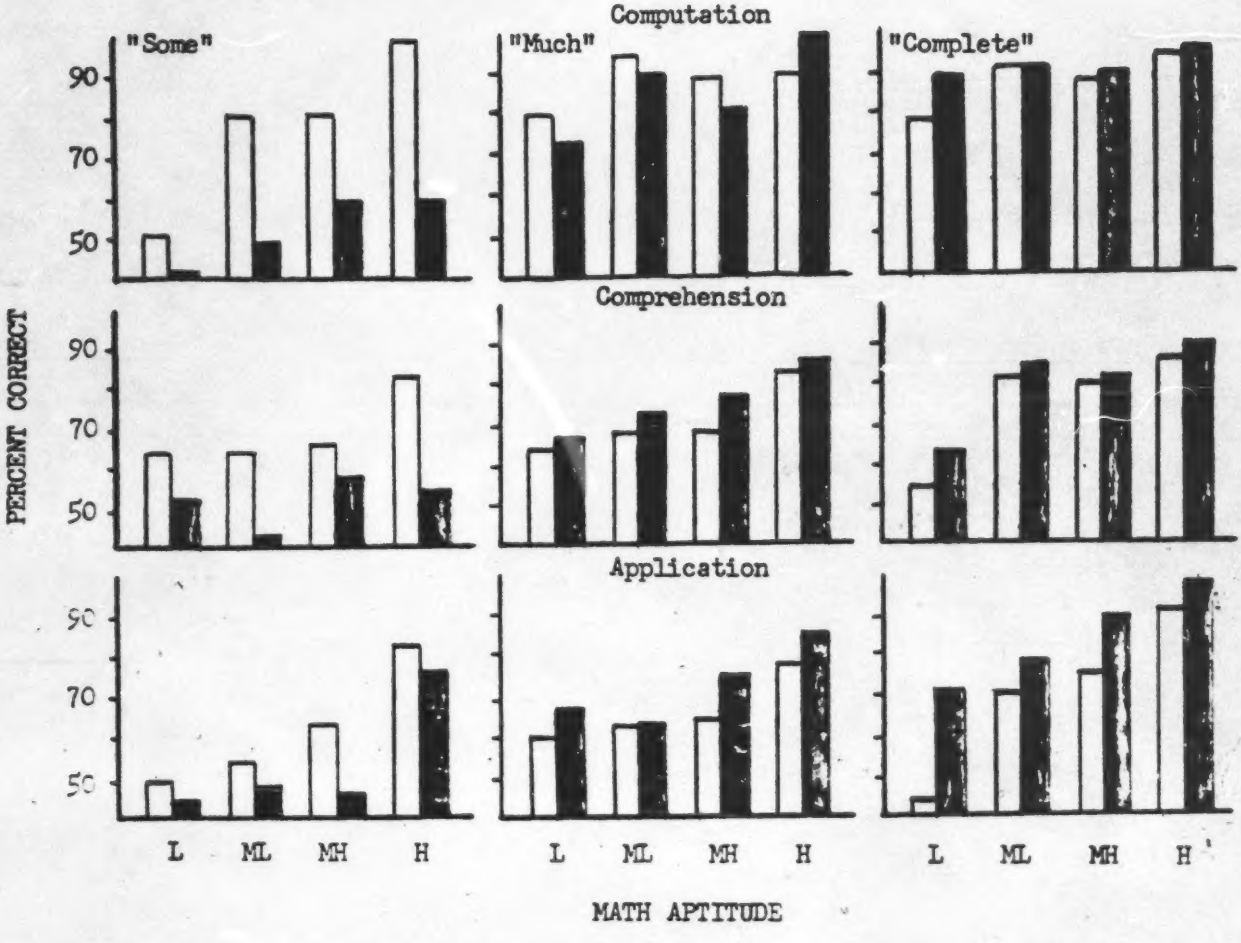

Fig. 2. Percent correct answers for each aptitude group as a function of confidence rating and mathematical demand, pre (white bars) and post (black bars).